

What is claimed is:

1. An ultrasonic cleaning apparatus which cleans a subject to be cleaned by utilizing oscillation generated by an ultrasonic oscillator, comprising:

a power amplifier for amplifying an amplitude of a signal to supply the signal as power to said ultrasonic oscillator;

a detector for detecting a state of said ultrasonic oscillator; and

a controller for controlling a frequency of said signal depending on an output detected by the detector,

wherein said power supplied to said ultrasonic oscillator is set to a range from 1W to 10 W.

2. The ultrasonic cleaning apparatus according to claim 1, wherein said detector is a phase comparator for obtaining a difference between a phase of a current flowing through said ultrasonic oscillator and a phase of a voltage applied to said ultrasonic oscillator and for generating the voltage in accordance with the phase difference.

3. The ultrasonic cleaning apparatus according to claim 2, wherein said controller is a voltage control oscillation device for generating a signal having a frequency in accordance with the voltage generated by the phase comparator and for controlling said frequency so that said phase difference is kept within a predetermined phase range.

4. The ultrasonic cleaning apparatus according to claim 3, wherein said voltage control oscillation device keeps said phase difference within $\pm 30^\circ$.

5. The ultrasonic cleaning apparatus according to claim 3, wherein an ultrasonic phone for amplifying an oscillation speed is jointed to said ultrasonic oscillator, and the maximum value of an oscillation speed at a tip end plane of the ultrasonic phone is set to a range from 1 m/s to 10 m/s.

6. The ultrasonic cleaning apparatus according to claim 3,
the ultrasonic cleaning apparatus further comprising:
a load state decision section for deciding based on the current flowing through said ultrasonic oscillator and the voltage applied to said ultrasonic oscillator whether a load is applied or not,

wherein, when no load is applied, said power amplifier regulates said power supplied to said ultrasonic oscillator to 1/2 that when the load is applied or less.

7. The ultrasonic cleaning apparatus according to claim 3,

5 the ultrasonic cleaning apparatus further comprising:

a load state decision section for deciding based on the current flowing through said ultrasonic oscillator and the voltage applied to said ultrasonic oscillator whether a load is applied or not,

10 wherein, when no load is applied, said voltage control oscillation device controls said frequency to regulate said phase difference to 60° or more.

8. An ultrasonic cleaning apparatus which cleans a subject to be cleaned by utilizing oscillation generated by an ultrasonic oscillator, comprising:

15 a power amplifier for amplifying an amplitude of a signal to supply the signal as power to said ultrasonic oscillator;

a detector for detecting a state of said ultrasonic oscillator; and

a controller for controlling a frequency of said signal depending on an output detected by the detector,

20 wherein said power supplied to said ultrasonic oscillator is set to a range from 1W to 10 W and a difference between a resonance frequency of said ultrasonic oscillator and an anti-resonance frequency thereof is regulated to 1 kHz or more.

9. An ultrasonic cleaning apparatus which cleans a subject to be cleaned by utilizing oscillation generated by an ultrasonic oscillator,

25 wherein a power supplied to said ultrasonic oscillator is set to a range from 1W to 10 W, and

30 wherein at least one passive element of a coil and a capacitor is connected in parallel to said ultrasonic oscillator, and a difference between a resonance frequency of a synthesis circuit and an anti-resonance frequency thereof close to the resonance frequency, the synthesis circuit being constituted by the passive element and the ultrasonic oscillator, is regulated to 1 kHz or more.

10. The ultrasonic cleaning apparatus according to claim 8, wherein said ultrasonic oscillator is a Langevin type piezoelectric oscillator, and a resonance frequency thereof is set to a range from 20 kHz to 100 kHz.

11. The ultrasonic cleaning apparatus according to claim 9, wherein a value of said coil is set to a range from 5 to 200 mH and a value of said capacitor is set to a range from 10 to 3000 pF.

12. The ultrasonic cleaning apparatus according to claim 1, wherein an adjusting circuit is provided between said power amplifier and said ultrasonic oscillator, the adjusting circuit being for adjusting an impedance between said power amplifier and said ultrasonic oscillator,

wherein said phase comparator is provided among said adjusting circuit, said ultrasonic oscillator and said passive element.

13. The ultrasonic cleaning apparatus according to claim 1,
the ultrasonic cleaning apparatus further comprising:
a switching transistor; and
a switch control section,

wherein said switch control section turns off said switching transistor until said phase difference becomes equal to a predetermined value, and turns on said switching transistor after said phase difference becomes equal to said predetermined value.

14. The ultrasonic cleaning apparatus according to claim 1, wherein a difference between a resonance frequency of said ultrasonic oscillator and an anti-resonance frequency thereof is regulated to 1.2 kHz or more.

15. The ultrasonic cleaning apparatus according to claim 1, wherein a difference between a resonance frequency of said ultrasonic oscillator and an anti-resonance frequency thereof is regulated to 1.5 kHz or more.

16. The ultrasonic cleaning apparatus according to claim 1, wherein at least one passive element of a coil and a capacitor is connected in parallel to said ultrasonic oscillator, and a difference between a resonance frequency of a synthesis circuit and an anti-resonance frequency thereof close to the resonance frequency is regulated to 1.2 kHz or more, the synthesis circuit being constituted by said passive element and said ultrasonic oscillator.

17. The ultrasonic cleaning apparatus according to claim 1, wherein at least one passive element of a coil and a capacitor is connected in parallel to said ultrasonic oscillator, and a difference between a resonance frequency of a synthesis circuit and an anti-resonance frequency thereof close to the resonance frequency is regulated to 1.5 kHz or more, the synthesis circuit being constituted by said passive element and said ultrasonic oscillator.

18. A method of controlling an ultrasonic cleaning apparatus which cleans a subject to be cleaned by oscillation generated by an ultrasonic oscillator, comprising the steps of:

amplifying an amplitude of a signal to supply the signal to said ultrasonic

10 oscillator;

obtaining a difference between a phase of a current flowing through said ultrasonic oscillator and a phase of a voltage applied to said ultrasonic oscillator, and generating a voltage in accordance with the phase difference; and

15 generating a frequency of said signal depending on the voltage generated in accordance with the phase difference, and controlling said frequency so that said phase difference is kept at a predetermined range,

wherein said power supplied to said ultrasonic oscillator is set to a phase range from 1W to 10W.

20 19. The method according to claim 18, wherein when said phase difference is controlled, the phase range of said phase difference is kept within $\pm 30^\circ$.

25 20. The method according to claim 18, wherein an ultrasonic phone for amplifying an oscillation speed is jointed to said ultrasonic oscillator, and the maximum value of the oscillation speed at a tip end plane of the ultrasonic phone is set to a range from 1m/s to 10 m/s.

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